SPECIFICATIONS

TITLE OF THE INVENTION

Method for processing magnetic resonance imaging image information and magnetic resonance imaging system

BACKGROUND OF THE INVENTION AND RELATED ART STATEMENT

This invention relates to a method for processing magnetic resonance imaging image information that is preferably used for a nondestructive inspection of an internal of a three-dimensional object such as a human body and also relates to a magnetic resonance imaging system used in the method.

Conventionally, X-ray photography has been widely used for inspecting an internal of a human body. The X-ray irradiating a human body transmits the human body, however, transmittance becomes low in bones. Then fracture of the bone can be diagnosed with an X-ray photograph.

However, there is a problem that X-rays cannot irradiate often on a human body because enormous quantity of X-rays irradiated on a human body will damage cellular of the human body.

In order to solve this problem, an approach has been made that a magnetic field is irradiated on a human body so as to inspect an internal of the human body with magnetic resonance spectral intensity distribution by making use of a magnetic resonance phenomenon. (Refer to, for example, non-patent document 1.)

Non-patent document 1

"Research of Structural Image Process for Optical Brain Function Measurement" by Masahiko Matuo, Hirofumi Hamada, Naohiro Fujikawa, Hideaki Ninomiya, Hideo Eda and Satoru Miyauchi, p55 of the Proceedings of Japan Soc. ME & BE Conference (May, 2002)

However, an image cannot be obtained at some portions such as a bone structure by an ordinal magnetic resonance imaging image. Then a new method is expected to inspect such portions by a nondestructive inspection.

In addition to the above case, there is a case in which an image cannot be obtained by an ordinal magnetic resonance imaging image in conducting a nondestructive inspection on an internal of a three-dimensional object. In order to deal with these cases a new method is being expected.

In order to solve the above problems the present claimed invention intends to provide a new method for a nondestructive inspection on an internal of three-dimensional object without harmful electromagnetic waves such as radioactive rays.

SUMMARY OF THE INVENTION

The method for processing magnetic resonance imaging image information in accordance with the present claimed invention is characterized by that a magnetic resonance spectral intensity value is measured at each of a plurality of measuring points that are arranged at predetermined intervals along a lengthwise direction, a crosswise

direction and a height direction on an object to be measured and several kinds of magnetic resonance imaging image information as a set of the magnetic resonance spectral intensity values measured at the measuring point are obtained by a plurality of different spectral intensity measuring methods with respect to the object to be measured, a magnetic resonance spectral intensity value at the predetermined position is obtained directly or indirectly from a measured results of the magnetic resonance spectral intensity values that is included in the magnetic resonance imaging image information and the predetermined position is set to be identical for all of the several varieties of magnetic resonance imaging image information with respect to each of the magnetic resonance imaging image information, and new image information at the predetermined position is derived by linear calculation between the spectral intensity values.

In accordance with the method, if we focus attention on, for example, that a magnetic longitudinal relaxation velocity of hydrogen nucleus in a water molecule is low and a magnetic transverse relaxation velocity thereof is high, it is possible to inspect inside of an object to be measured in a nondestructive manner without irradiating harmful X-rays such as to derive an image of a bone structure by eliminating a spectrum originating hydrogen nucleus in a water molecule by obtaining a magnetic resonance imaging image of a magnetic longitudinal relaxation measurement and a magnetic resonance imaging image of a magnetic transverse

relaxation measurement conducted on a living organism.

As a preferable mode to conduct an inspection by the use of the magnetic resonance imaging image represented is that the new image information is information showing a bone structure.

As an example of the method to conduct the inspection by the use of the magnetic resonance imaging image represented is that magnetic resonance imaging image information by a magnetic longitudinal relaxation measurement and magnetic resonance imaging image information by a magnetic transverse relaxation measurement are obtained.

Further, as another example of the method to conduct the inspection by the use of the magnetic resonance imaging image represented is that magnetic resonance imaging image information by a nuclear density measurement is further obtained in addition to the magnetic resonance imaging image information by the magnetic longitudinal relaxation measurement and the magnetic resonance imaging image information by the magnetic transverse relaxation measurement.

In case the magnetic resonance imaging image is obtained, a measuring position is often set at different positions according to a kind of measurement. Then in order to obtain spectral intensity values at an identical predetermined position by several different measurements, it is preferable that with respect to at least one kind of the magnetic resonance imaging image information, a magnetic resonance spectral intensity value at the predetermined

position is obtained by interpolation of the measured results of the magnetic resonance spectral intensity value that is included in the magnetic resonance imaging image information. In accordance with the arrangement, for example, a measuring point of a kind of magnetic resonance imaging image information is set as a predetermined position and other magnetic resonance imaging image information is obtained from magnetic resonance spectral intensity of the magnetic resonance imaging image information at the predetermined position by interpolation of magnetic resonance spectral intensity values of the other magnetic resonance imaging image information at the predetermined position, which makes it possible to obtain new image information with ease.

In order to obtain the magnetic resonance imaging image with ease, it is preferable that the magnetic resonance spectral intensity value is a hydrogen nucleus magnetic resonance spectral intensity value. This is because that a lot of hydrogen atoms are included in a living body and sensitivity of nucleus magnetic resonance of hydrogen atom is high compared with most of other nuclei.

Further, in order to obtain a condition of a bone more accurately, it is preferable that a comparison is further made between new image information obtained by a linear calculation of the spectral intensity values at the predetermined position and image information obtained by an X-ray computed tomography. It is possible to obtain an image data showing a position and/or a condition of a bone

directly if the X-ray computed tomography is uses. In the present claimed invention "a comparison is further made between new image information obtained by a linear calculation of the spectral intensity values at the predetermined position and image information obtained by an X-ray computed tomography" is a concept including that the image information is output simultaneously on a same display and the image information is output to a printing media such as a paper so as to make the image information visible based on the image information and a linear calculation is made between a spectral intensity values of the image information at the predetermined position so as to derive further new information.

As a magnetic resonance imaging system that is used in the method for processing magnetic resonance imaging image information it is preferable that the system further functions at least as an information obtaining portion that obtains magnetic resonance imaging image information, a first obtained image information storing portion that stores magnetic resonance imaging image information obtained by a predetermined method, a second obtained image information storing portion that stores magnetic resonance imaging image information obtained by a method different from the predetermined method, a linear calculation portion that conducts a linear calculation based on the magnetic resonance imaging image information stored in the first obtained image information storing portion and the magnetic resonance imaging image information stored in the second

obtained image information storing portion, a calculated result image information storing portion that stores new image information as a calculated result of the linear calculation portion and an image output portion that outputs an image based on the image information stored in the calculated result image information storing portion.

In addition if the system also functions as an interpolating calculation portion that three-dimensionally aligns the magnetic resonance imaging image information stored in the first obtained image information storing portion with the magnetic resonance imaging image information stored in the second obtained image information storing portion and a spectral intensity value at the predetermined position set identical to other measuring point is obtained by interpolation of the magnetic resonance imaging image information stored in either one of the first and the second obtained image information storing portions, it is possible to obtain a spectral intensity value at the same predetermined position and to make a linear calculation even though a measuring point varies between the magnetic resonance imaging image information stored in the first obtaining image information storing portion and that in the second obtaining image information storing portion.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a general view showing an MRI system used in a method for processing magnetic resonance imaging image information in accordance with one embodiment of the present

claimed invention.

Fig. 2 is a functional block diagram of the MRI system in accordance with the embodiment.

Fig. 3 is a general view showing a stored state of magnetic resonance imaging image information obtained by the MRI system in accordance with the embodiment.

Fig. 4 is a view showing a tendency of signal intensity value of each portion of the image obtained by the MRI system in accordance with the embodiment.

Fig. 5 is a view showing an example of the image obtained with a magnetic longitudinal relaxation measurement by the MRI system in accordance with the embodiment.

Fig. 6 is a view showing an example of the image obtained with a magnetic transverse relaxation measurement by the MRI system in accordance with the embodiment.

Fig. 7 is a flow chart showing a flow of a step in the method for processing magnetic resonance imaging image information in accordance with the embodiment.

Fig. 8 is a flow chart showing a flow of a step in the method for processing magnetic resonance imaging image information in accordance with the embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present claimed invention will be described in detail with reference to the accompanying drawings.

A method for processing magnetic resonance imaging image information in accordance with the embodiment uses a

magnetic resonance imaging system (hereinafter called as MRI system) M shown in Fig. 1. Magnetic resonance imaging image information by a magnetic longitudinal relaxation measurement (hereinafter called as T_1 measurement) and magnetic resonance imaging image information by a magnetic transverse relaxation measurement (hereinafter called as T_2 measurement) are obtained with the MRI system M.

The MRI system M has the same arrangement as that of a universally known and widely used system for a medical checkup and acts the same so as to obtain the magnetic resonance imaging image information by the T_1 measurement and the magnetic resonance imaging image information by the T_2 measurement. In this embodiment, an *x* axis is set along a horizontal direction of a human body, a *y* axis is set along a cross direction thereof and a *z* axis is set along a vertical direction thereof and an *x*-*y* plane is a sliced image plane on which a matrix is set. Measuring points are set at a same pitch along the horizontal direction and the cross direction of the body of a subject as an object to be measured, namely, along the *x* axis and the *y* axis with a same matrix score.

The MRI system M, whose functional block diagram is shown in Fig.2, functions as an information obtaining portion 1 that obtains the magnetic resonance imaging image information, a first obtained image information storing portion 2 that stores the magnetic resonance imaging image information obtained by the T_1 measurement, a second obtained image information storing portion 3 that stores th magnetic

resonance imaging image information obtained by the T_2 measurement, and an image output portion 8 that outputs an image. The first obtained image information storing portion 2 and the second obtained image information storing portion 3 are arranged in a memory space of an internal memory of the MRI system M. The obtained magnetic resonance imaging image information is, as shown in Fig. 3, stored in the first obtained image information storing portion 2 and the second obtained image information storing portion 3. More specifically, a spectral intensity value at each point is indicated on a basis of 16-bit (65536) with the minimum of 0 and the maximum of 65535 and a spectral intensity value at a matrix point (x,y) on a sliced image plane of the z th piece is stored in the x th row and the y th column on the z th piece. The spectral intensity value of water is low by the T_1 measurement and high by the T_2 measurement. The spectral intensity value of a bone is low by both the T_1 measurement and the T_2 measurement. The spectral intensity value of a brain is middle by both the T_1 measurement and the T_2 measurement, however, highish by the T_1 measurement. The spectral intensity value of skin is middle by the T_1 measurement and highish by the T_2 measurement. The above-mentioned tendency is shown in Fig. 4. An example of the image obtained by the T_1 measurement is shown in Fig. 5 and an example of the image obtained by the T_2 measurement is shown in Fig. 6 respectively.

In this embodiment, the spectral intensity value of the magnetic resonance imaging image information obtained by

the T_1 measurement and the spectral intensity value of the magnetic resonance imaging image information obtained by the T_2 measurement at the same position are linear-calculated so as to obtain image information showing a bone structure of a head portion.

More specifically, as shown in Fig. 2, the MRI system M further functions as an interpolating processing portion 4, an interpolating processing result information storing portion 5, a linear calculating portion 6 and a calculated result image information storing portion 7. The interpolating processing result information storing portion 5 and the calculated result image information storing portion 7 are arranged in the memory space. The interpolating processing portion 4 three-dimensionally aligns the magnetic resonance imaging image information obtained by the T_1 measurement and the magnetic resonance imaging image information obtained by the T_2 measurement and a spectral intensity value at the same point as the measured point used for the T_1 measurement is obtained by interpolation of the magnetic resonance imaging image information obtained by the T_2 measurement. The interpolating processing result information storing portion 5 stores a calculated result by the interpolating processing portion 4. The linear calculating portion 6 inverts each bit of the spectral intensity value stored in the first obtained image information storing portion 2 and also calculates difference between the inverted result and the spectral intensity value stored in the interpolating processing

result information storing portion 5 multiplied by a constant number *a*. The constant number *a* is so set that a calculated result of a spectral intensity value of water is zero. The calculated result image information storing portion 7 stores calculated result image information as a set of the calculated results.

A flow of concrete steps is shown below with reference to Fig. 7 and Fig. 8. First, the information obtaining portion 1 conducts the T_1 measurement and a result of the T_1 measurement is stored in the first obtained image information storing portion 2. (S1) Next, the information obtaining portion 1 conducts the T_2 measurement and a result of the T_2 measurement is stored in the first obtained image information storing portion 2. (S2) The magnetic resonance imaging image information obtained by the T_1 measurement and the magnetic resonance imaging image information obtained by the T_2 measurement are three-dimensionally aligned, a spectral intensity value at the same point as the measured point used for the T_1 measurement is obtained by interpolation of the magnetic resonance imaging image information obtained by the T_2 measurement and then the obtained spectral intensity value is stored in the interpolating processing result information storing portion 5. (S3) More concretely, as mentioned above, since a size of each matrix is the same and a width between adjacent sliced image planes is made broad, a spectral intensity value at a measuring point to be obtained is obtained by linear interpolation of spectral intensity values of the same grid

in a matrix as that of the measuring point on the two sliced image planes nearest to the measuring point. The flow so far is shown in Fig. 7. As shown in Fig. 8, an x direction of the matrix, namely a variable x showing a row in Fig. 3, a y direction of the matrix, namely a variable y showing a column in Fig. 3 and a variable z showing a number of a sliced image plane are reset to 1. (S4) With respect to a signal intensity of the x th row, the y th column on the z th piece, a value that is a spectral intensity value of the x th row, the y th column on the z th piece stored in the interpolating processing result information storing portion 5 multiplied by a is subtracted from a value that is each bit of a spectral intensity value is inverted of the x th row, the y th column on the z th piece stored in the first obtaining image information storing portion 2. (S5, a linear calculation step) More specifically, a linear calculation is conducted based on

$t=(65535-t_1)-at_2$

wherein a spectral intensity value to be obtained is t, a spectral intensity value obtained by the T_1 measurement is t_1, and a spectral intensity value obtained by the T_2 measurement is t_2, and a calculated result is stored at the x th row, a y th column on the z th piece of the calculated result image information storing portion 7. The stored x is determined whether it coincides with a number of a grid of the matrix. (S6) If the x does not coincide with the number of the grid of the matrix, 1 is added to the x (S7) and return to the linear calculation step. If the x coincides with the number

of the grid, the stored *y* is determined whether it coincides with a number of the grid of the matrix. (S8) If the *y* does not coincide with the number of the grid of the matrix, 1 is added to the *y* and the *x* is reset to 1 (S9) and return to the linear calculation step. If the *y* coincides with the number of the grid, the *z* is determined whether it coincides with a number of a piece of the sliced image. (S10) If the *z* does not coincide with the number of the piece, 1 is added to the *z* and the *x* and the *y* are reset to 1 (S11) and return to the linear calculation step. If the *z* coincides with a number of the sliced image planes, an image is output based on the image information stored in the calculation result image information storing portion 7 by the above steps. (S12)

In accordance with the above steps of obtaining image information, it is possible to obtain a data of a bone structure shape that cannot be obtained by an ordinary MRI measurement inspection without using radiation rays that is harmful to a human body. Especially, if the method for processing magnetic resonance imaging image information method is used for a head portion of a human, it is possible to obtain a shape of a skull, which enables to determine a position of fracture of the skull more safely.

The present claimed invention is not limited to the above-described embodiment.

For example, magnetic resonance imaging image information by a hydrogen nucleus density measurement may be used. Further, spectral intensity values of three kinds of

image information, namely magnetic resonance imaging image information by the hydrogen nucleus density measurement, magnetic resonance imaging image information by the magnetic longitudinal relaxation measurement and the magnetic resonance imaging image information by the magnetic transverse relaxation measurement at a predetermined position may be linearly calculated so as to obtain new image information. The spectral intensity values at each position by the hydrogen nucleus density measurement show a tendency different from the spectral intensity values at each position by the magnetic longitudinal relaxation measurement and by the magnetic transverse relaxation measurement, as shown in Fig. 4. Then if the spectral intensity value at the predetermined position by the hydrogen nucleus density measurement is also used as a variable of the linear calculation, further new information can be obtained.

The above-mentioned method for processing magnetic resonance imaging image information may be used to obtain information on a portion other than a bone structure of human, further information on other than human. In this case, an algorithm of the linear calculation may be set arbitrarily tailored to a kind of information to be obtained.

Further, the predetermined position is not determined based on a measuring point of one kind of magnetic resonance imaging image information but may be determined independently from the measuring point of the magnetic resonance imaging image information obtained by the MRI

system and the spectral intensity value at the predetermined position of all of the obtained magnetic resonance imaging image information may be obtained by interpolation. In addition, an algorithm of interpolation is not the linear interpolation used in the above-described embodiment and may be other algorithm.

The nucleus magnetic resonance spectral may use other atomic nucleus such as a carbon nucleus or a nitrogen nucleus in addition to a hydrogen nucleus.

In addition, comparison may be made between image information obtained by the magnetic resonance imaging image information and image information obtained by an X-ray computed tomography. More concretely, the image information obtained by the magnetic resonance imaging image information and the image information obtained by the X-ray computed tomography are output simultaneously on a same display and both of the image information are output to a printing media such as a paper so as to make the image information visible or a linear calculation is made between a spectral intensity value of the image information obtained by the magnetic resonance imaging image information at the predetermined position and a spectral intensity value of the image information obtained by the X-ray computed tomography at the predetermined position so as to derive further new information. In accordance with the arrangement, a state of a bone can be obtained more accurately by comparison of the information directly showing a position of the bone by the X-ray computed tomography.

Other arrangement may be variously modified without departing from the spirit of the invention.

As mentioned above, since the present claimed invention derives new image information showing an internal state of an object to be measured such as image information showing a bone structure by linear calculation of a plurality of magnetic resonance imaging image information, there is no need of nuclear radiation such as an X-ray that is harmful to a human body when a non-destructive inspection is conducted on an inside of the object to be measured, thereby to improve safety for a non-destructive inspection like this.